

# Measles Vaccination Levels of Children Enrolled in WIC during the 1991 Measles Epidemic in New York City

## ABSTRACT

**Objectives.** This study assessed measles vaccination rates and risk factors for lack of vaccination among preschool children enrolled in the Special Supplemental Food Program for Women, Infants, and Children (WIC) during the 1991 measles epidemic in New York City.

**Methods.** Children aged 12 to 59 months presenting for WIC certification between April 1 and September 30, 1991, at six volunteer WIC sites in New York City were surveyed.

**Results.** Of the 6181 children enrolled in the study, measles immunization status was ascertained for 6074 (98%). Overall measles coverage was 86% (95% confidence interval [CI] =  $\pm 1\%$ ) and at least 90% by 21 months of age (95% CI =  $\pm 1\%$ ). Young age of the child, use of a private provider, and Medicaid as a source of health care payment were risk factors for lack of vaccination ( $P < .001$ ).

**Conclusions.** During the peak of a measles epidemic, measles immunization rates were more than 80% by 24 months of age in a sample of WIC children. The ease of ascertaining immunization status and the size of the total WIC population underscore the importance of WIC immunization initiatives. (*Am J Public Health.* 1996;86:1551-1556)

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## Introduction

During 1989 to 1991, a nationwide resurgence of measles occurred in which 55 467 cases, 11 251 hospitalizations, and 136 deaths were reported to the Centers for Disease Control (CDC, unpublished data). New York City was a major center of the resurgence, reporting 3148 confirmed cases (the largest number of reported cases of any locality during the 1991 epidemic peak), 1109 hospitalizations, and 24 deaths. In New York, as in the rest of the nation, the attack rate was highest in children below 5 years of age, and 94% of these children with measles were unvaccinated (New York City Department of Health, unpublished data). A 1990 study in New York City of 45 unvaccinated measles cases in children below 5 years of age found that, at time of rash onset, 63% of those children had been enrolled in the Special Supplemental Food Program for Women, Infants, and Children (WIC).<sup>1</sup>

In January 1991, the New York State Department of Health required that WIC sites screen all children for immunization status and refer those in need of immunization for services. Immunization rates for measles among children enrolled in WIC were reported to be greater than 80% by 24 months of age,<sup>2</sup> a level thought to provide herd immunity against measles outbreaks.<sup>3</sup> These unverified figures raised important questions concerning immunization and outbreak control initiatives, and in the spring of 1991 at the peak of New York City's measles epidemic, the New York State Department of Health and the National Immunization Program of the CDC sponsored a study of rates and

risk factors for verified measles immunization among children enrolled in WIC.

## Methods

### Study Population

Of the 42 WIC providers in New York City, six sites were identified that met the following criteria: (1) enrollment of more than 500 children aged 12 to 59 months, and (2) willingness to participate in a subsequent immunization intervention trial whose results have already been reported.<sup>4</sup> Each site was located in a different neighborhood known to have high measles activity. The subjects of this study were children aged 12 to 59 months whose families presented for certification or semi-annual recertification at these WIC sites between April 1 and September 30, 1991.

At all study sites, a study clerk enrolled each child in the study and interviewed the family to obtain demographic, health care, and measles vaccination information.

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**TABLE 1—Comparison of the Characteristics of Children Aged 12 through 59 Months Enrolled in Six WIC Study Sites with Those of the General Population Enrolled in WIC and with Those of Unvaccinated Children with Measles, New York City, April to September 1991**

	General WIC Population <sup>a</sup> (12–59 Months) (n = 78 209)	WIC Study Population (12–59 Months)		Unvaccinated Children with Measles <sup>b</sup> (12–59 Months) (n = 45)
		All (n = 6181)	Unvaccinated (n = 837)	
Child's age, median	...	29 mo	14 mo	15 mo
12–23 mo, %	41	38	75	76
24–35 mo, %	28	26	14	16
36–47 mo, %	20	21	8	7
48–59 mo, %	12	14	4	0
Racial/ethnic group, exclusive				
Hispanic, %	46	55	56	67
Black, %	39	40	39	18
White and Asian, %	15	5	5	15
Family situation				
Single parent, %	...	71	74	...
Grandparent/guardian, %	...	4	3	...
Both parents, %	...	24	24	...
Mother's age, median	...	29 y	27 y	...
Usual health care provider				
Private physician, %	...	33	35	32
Clinic, %	...	67	65	67
Health care payment source				
Medicaid, %	...	81	83	75
Private insurance, %	...	8	8	15
Self-pay, %	...	9	7	10
Time in WIC, median for family	...	18 mo	12 mo	...
Nutritional risk factors, not exclusive				
Hemoglobin < 110 g/L (11 g/dL), %	48	41	42	...
Weight < 10th percentile, %	17	6	6	...
Height < 10th percentile, %	23	9	11	...
Weight/height < 10th percentile, %	18	8	11	...

Note. WIC = Special Supplemental Food Program for Women, Infants, and Children.

<sup>a</sup>All children aged 12–59 months who presented for certification to New York City WIC during the period of the study, as obtained from WIC computer tapes.

<sup>b</sup>From a study of unvaccinated measles cases in New York City (see Hutchins et al.<sup>1</sup>).

**TABLE 2—Age-Specific Measles Immunization Levels among Children Aged 12 through 59 Months Enrolled in Six WIC Study Sites, New York City, April to September 1991**

Age, mo	Enrolled	Immunized before Enrollment		
		No.	%	95% CI
12–14	832	393	47	44, 51
15–17	447	373	83	80, 87
18–20	658	587	89	87, 92
21–23	426	385	90	88, 93
24–59	3818	3607	94	94, 95
Overall	6181	5345	86	86, 87

Note. WIC = Special Supplemental Food Program for Women, Infants, and Children; CI = confidence interval.

follow-up visit (at least every 2 months) until proof of measles immunity was provided or the study period was over.

A child was considered vaccinated if a record was obtained of measles immunization or if a physician reported to study personnel that measles immunization had been administered to the child on a specific date. A child was considered unvaccinated if either the parent or a parent-identified health care provider reported that the child had not received measles immunization. The immunization status was considered to be unascertained if none of the evidence listed above could be obtained.

### Immunization Status Ascertainment

Eligibility for measles vaccine was determined according to the recommendations of the Advisory Committee on Immunization Practices<sup>5</sup> and the policies

of the New York City Department of Health, which since 1986 had recommended that measles vaccination be provided at 12 months of age. Families of eligible children were seen at every

### Data Entry and Analysis

Study data forms were collected weekly and entered into a database program on a personal computer. Data were analyzed with the SAS program for

personal computers.<sup>6</sup> Children with unascertained vaccination status were treated as if they were unvaccinated. The results were compared with those obtained by two alternate approaches: treating such children as vaccinated or excluding these children from analysis.

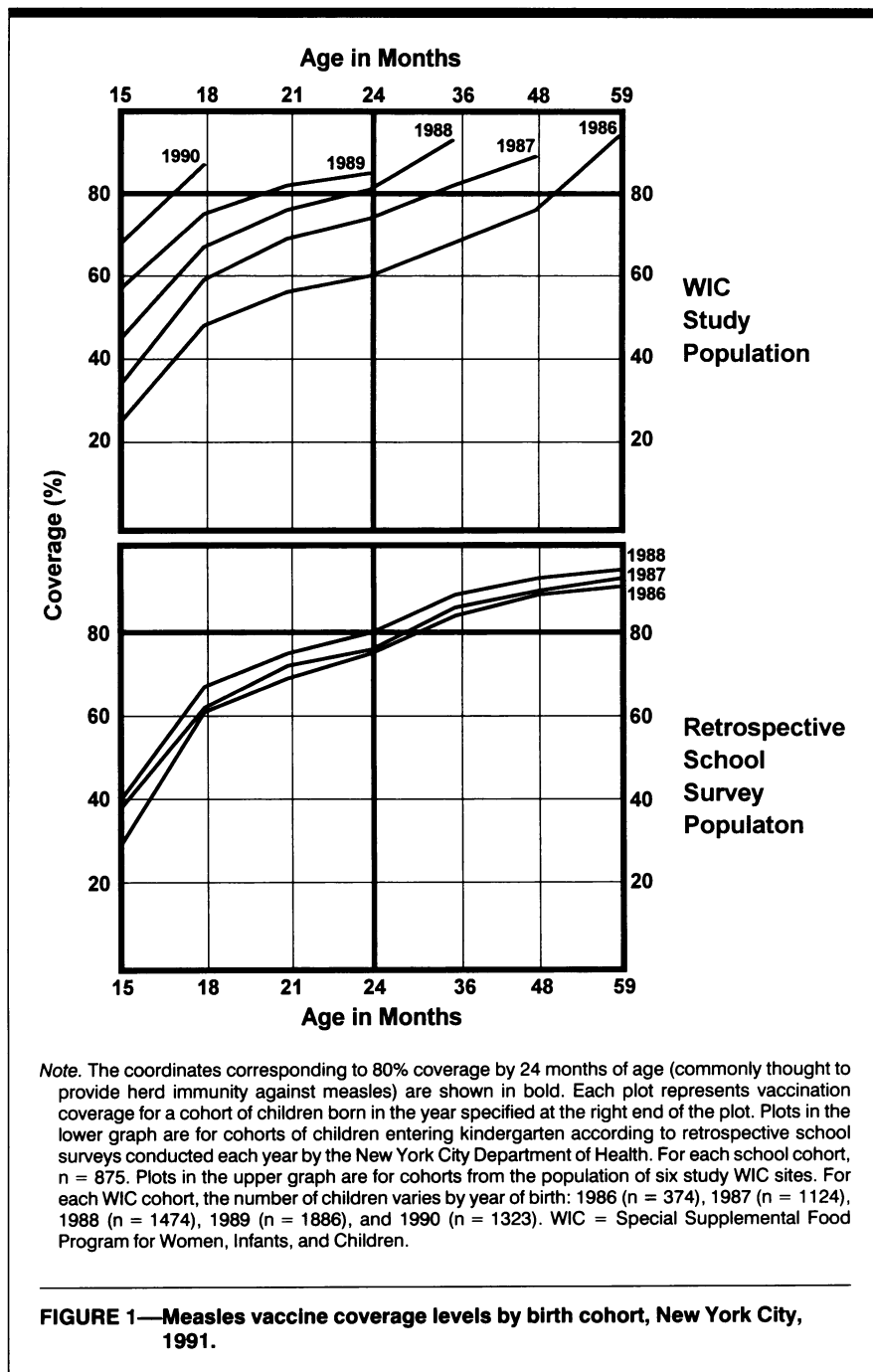
To assess the representativeness of the study population to the general WIC population, demographic data concerning the study population were compared with data from WIC computer tapes concerning all children aged 12 to 59 months whose families presented for certification or recertification to all WIC sites in New York City during the same period as the study. To assess the similarity of the study population to the population at risk for measles, the demographic characteristics of the study population were also compared with those of the 45 previously described unvaccinated New York City children aged 12 to 59 months with measles.<sup>1</sup> To compare age-specific vaccination rates in WIC with rates in the general New York City population, the study population was divided analytically into cohorts based on year of birth, and vaccination rates were compared with retrospective school survey data collected annually by the city's Department of Health according to standard CDC methods recommended to all localities using federal funds. In these school survey data, the immunization records of 25 randomly selected children enrolling for kindergarten in each of 35 randomly selected schools throughout New York City ( $n = 875$ ) are used to estimate vaccination coverage rates for the year's school entry cohort.<sup>7</sup>

Bivariate and stratified analysis of risk factors for lack of measles vaccination were carried out. To this end, the Cochran-Mantel-Haenszel procedure was used to assess the association for categorical variables, and the Wilcoxon Rank Sum test was used to test differences among groups for continuous variables. A stepwise logistic regression was performed, with lack of immunization at enrollment as the dependent variable and risk factors identified as significant ( $P < .05$ ) by bivariate analysis as the candidate independent variables.

## Results

### Characteristics of the Study Population

A total of 6181 children aged 12 to 59 months were enrolled in the study between April 1 and September 30, 1991. The measles immunization status of 6074 (98%) of enrollees was ascertained. This



**FIGURE 1—Measles vaccine coverage levels by birth cohort, New York City, 1991.**

was facilitated by 4874 (79%) of families presenting vaccination documentation at WIC certification, which reflected the high degree of compliance with the state requirement put into effect 4 months before the study began that all WIC sites screen the vaccination status of each enrollee.

When the study population was compared with all children 12 to 59 months of age presenting for WIC certification in New York City during the same period, the age distribution was similar, but the study population had a signifi-

cantly greater proportion of Hispanics (55% vs 46%) and a smaller proportion of Whites (5% vs 15%) (Table 1). Since this study excluded children under 12 months of age and evaluated mother's age at time of study enrollment rather than at child's birth, data from the study population probably underestimate WIC's capture of young and teenage mothers. Unvaccinated study children did not differ by more than 3% from the general study population in race/ethnicity, family situation, nutritional indexes, or use of health care providers and payment sources, but

**TABLE 3—Risk Factors for Lack of Measles Immunization among Children Aged 12 through 59 Months Enrolled in Six WIC Study Sites, New York City, April to September 1991**

Factor	Enrolled	Unimmunized at Enrollment		Bivariate Analysis <sup>a</sup>		Multivariate Analysis <sup>b</sup>	
		No.	%	Risk Ratio	95% CI	Odds Ratio	95% CI
Child's age							
12–14 mo	832	439	53	9.55*	8.25, 11.05	20.31*	16.66, 24.76
15–23 mo	1531	186	12	2.20*	1.82, 2.65	2.45*	1.99, 2.45
24–59 mo	3817	211	6	Referent		Referent	
Racial/ethnic group							
Hispanic	3372	468	14	1.12	0.83, 1.51		
Black	2471	327	13	1.07	0.78, 1.45		
White and Asian	322	40	12	Referent			
Family situation							
Single parent	4410	617	14	1.06	0.91, 1.23		
Grandparent/guardian	269	21	8	0.59*	0.38, 0.91		
Both parents	1497	198	13	Referent			
Mother's age							
< 20 y	262	53	20	1.77*	1.36, 2.30		
20–29 y	3069	457	15	1.30*	1.14, 1.49		
≥ 30 y	2838	324	11	Referent			
Usual health care provider							
Private physician	2014	295	15	1.20*	1.02, 1.41	1.41*	1.14, 1.74
Clinic linked to WIC site	2241	307	14	1.12	0.96, 1.31	1.09	0.89, 1.35
Clinic not linked to WIC site	1897	232	12	Referent		Referent	
Health care payment source							
Medicaid	4996	688	14	1.32*	1.02, 1.69	1.52*	1.10, 2.10
Private insurance	463	67	14	1.38	0.99, 1.93	1.61*	1.05, 2.47
Self-pay	535	56	10	Referent		Referent	
Family's time in WIC							
< 12 mo	1829	352	19	3.62*	2.97, 4.42		
12–23 mo	2115	366	17	3.26*	2.67, 3.98		
≥ 24 mo	2222	118	5	Referent			
Nutritional risk factors							
Hemoglobin g/L							
< 110	2507	350	14	1.06	0.93, 1.20		
≥ 110	3674	486	13	Referent			
Weight percentile							
< 10th	373	53	14	1.05	0.82, 1.36		
≥ 10th	5808	783	13	Referent			
Height percentile							
< 10th	574	92	16	1.21	0.99, 1.47		
≥ 10th	5607	744	13	Referent			
Weight/height percentile							
< 10th	505	90	18	1.36*	1.11, 1.65		
≥ 10th	5676	746	13	Referent			

Note. WIC = Special Supplemental Food Program for Women, Infants, and Children; CI = confidence interval.

<sup>a</sup>Ratios followed by an asterisk are statistically significant ( $P < .05$ ).

<sup>b</sup>For multivariate results, only variables containing statistically significant ( $P < .05$ ) factors are shown.

they were significantly younger (median 14 vs 29 months,  $P < .001$ ). When the unvaccinated WIC study population was compared with the group of 45 unvaccinated 12- to 59-month-old children with measles investigated during the 1990 epidemic in New York City,<sup>1</sup> the patterns of use of health care providers, the payment sources, and the age distribution were not significantly different although the proportion of Hispanics and Blacks together was higher in the WIC study population (95% vs 85%,  $P = .002$ ).

### Immunization Rates

No site had measles immunization rates below 80% for children 21 to 23 months of age or older (Table 2). When the 107 children whose vaccination status could not be ascertained were either categorized as vaccinated or excluded from analysis, immunization rates increased slightly, from 86% to 88%.

For the three cohorts of entering kindergarteners for which data are available, measles immunization ranged be-

tween 75% and 80% at 24 months, with a rate of improvement of less than 5% per year (Figure 1). In contrast, coverage for the older WIC cohorts was lower, but each successive WIC cohort improved by 5% to 10% compared with the previous cohort.

### Risk Factors for Lack of Immunization

In bivariate analysis and in a logistic regression model, the child's age was the dominant risk factor for lack of vaccination, but significant risks were also created

by the use of a private physician as a usual health care provider and Medicaid as a health payment source (Table 3). No interactions among these factors were identified. Other factors identified as risks in bivariate analysis lost significance when either stratified by or paired in a logistic model with child's age. When the analysis was repeated for each individual WIC site, child's age was always the dominant risk factor for lack of vaccination ( $P < .0001$ ) but provider type and payment source did not consistently retain statistical significance. The analysis was also repeated with children whose immunization status was unascertained either being treated as vaccinated rather than as unvaccinated, or being excluded from analysis. In this case, all risk factors in the model described above retained their statistical significance and relative importance, and no other factors improved the fit of the model.

## Discussion

We investigated the characteristics and measles immunization status of 6181 preschool children enrolled in WIC during a major measles epidemic in New York City in 1991. We found that measles vaccination rates were surprisingly high—at least 90% for those older than 21 months. Since we required documentary evidence of measles vaccination to classify a child as vaccinated, and since the study ascertainment rate for immunization status exceeded 98%, it appears unlikely that these vaccination rates are overestimates. It is possible that the study population differed from the general WIC population or from a subpopulation at increased risk for measles. However, for accessible variables, we found that our study population resembled the general New York City WIC preschool population enrolled during the same period as the study was conducted, and our unvaccinated study population resembled that of New York City's unvaccinated preschool measles cases.

The improvement in immunization for each birth cohort in WIC suggests that the WIC population may have had worse measles vaccination coverage in the past. However, we found no convincing evidence that this improvement could be attributed to vaccination activity during the outbreak of the previous year. Since WIC requires a well-child care visit at 12 months of age and since the major immunization improvements over time appeared to arise from improved uptake

of measles vaccine in the 12- to 15-month age group, the WIC policy of requiring preventive care at 12 months may have played a central role in the steady rise in coverage among WIC children.

Whatever the cause, age-specific immunization rates for the WIC study population exceeded the threshold level of 80% for 2-year-olds that a study of a measles outbreak in Milwaukee in 1989/90 estimated to confer herd immunity on preschool children in census tracts.<sup>3</sup> Children enrolled in WIC do not constitute a geographical population, so concepts of herd immunity may not apply. However, each study site was located in a zone of high measles activity, no site had an age-specific immunization rate below 80% at 24 months, the study took place at the peak of New York City's measles epidemic, and WIC-enrolled children constituted 63% of the city's unvaccinated measles cases.

Outbreaks of measles have often occurred in school populations where vaccination and immunity exceed 95%.<sup>8-10</sup> Given the demographic changes that have brought urban preschoolers together in licensed or unlicensed day care, WIC, public assistance, medical waiting rooms, and other group environments, transmission may occur in certain preschool populations with an efficiency comparable to that of school outbreaks. These data suggest that levels of vaccination comparable to those needed to prevent school-based outbreaks may be necessary to prevent outbreaks of measles in certain preschool populations of high-risk children. With measles immunization now above 80% for the nation as a whole,<sup>11</sup> the National Immunization Program, as part of a national measles elimination strategy, is focusing efforts on raising coverage in areas at high risk for disease transmission.

It was unexpected that children enrolled in Medicaid should be at a 32% (95% confidence interval [CI] = 2%, 69%) increased risk for lack of vaccination compared with children whose families paid for health care themselves. At the time of this study, Medicaid provided a reimbursement fee of \$2 for administration of vaccination. Unpublished data from the CDC suggest that in 1990, \$10 was the minimum administration fee that would allow a Georgia public clinic employing a nurse to break even for vaccination; the break-even point for a New York City private physician would certainly have been more. Thus, vaccination of a Medicaid child in New York may well have inflicted an obligatory fiscal loss

on a provider, creating an incentive not to vaccinate.

A recent analysis of the National Medical Expenditure Survey found that, among persons who failed to receive preventive services, Medicaid recipients were the most poorly immunized, lagging behind those who were uninsured.<sup>12</sup> In a study of neonatal hepatitis B immunization in New York City, children enrolled in Medicaid were at increased risk of undervaccination when compared with children who either had or did not have health insurance.<sup>13</sup> Other studies have found receipt of Medicaid a risk factor for undervaccination of inner-city children<sup>14</sup> and for physicians referring children out of their practice for vaccination.<sup>15-17</sup> The rapid shift of Medicaid-enrolled children into managed care makes the relationship of Medicaid to undervaccination a high priority for further research.

Children whose usual health care providers were private physicians were at a 20% (95% CI = 2%, 41%) increased risk for lack of vaccination compared with children who attended clinics. Immunization rates among private physicians may have been low for the 12- to 15-month age group because these physicians chose to defer vaccination to 15 months of age rather than follow the recommendations of the New York City Department of Health to begin vaccination at 12 months of age. This lowered age had been publicized and promoted in the city since 1986 but may have been more fully adhered to in the public sector, where a chain of command can speed the implementation of policy changes. However, low immunization rates for all antigens have been found among children seen by some inner-city private physicians,<sup>18</sup> and the use of a private provider was found to be a risk factor for undervaccination among minority children in Los Angeles.<sup>14</sup> Since approximately half of all New York City vaccinations take place in the private sector (New York City Department of Health, unpublished data), research is needed to identify reimbursement and other strategies that favor high coverage in the private sector.

The dominant influence of young age is logical (older children have more time to get vaccinated) and tends to simplify measles immunization initiatives in WIC. A clerk need not create complex and perhaps controversial profiles involving race, family status, and other factors to estimate the risk of undervaccination.

This study had a number of limitations. The study children were from six

volunteer sites whose populations may not be completely representative of the general WIC population. Data concerning other vaccinations were not collected in our study, so it is not possible to state whether the findings for measles immunization rates and risks apply to vaccine coverage in general.

Currently WIC enrolls more than 98 000 (72%) of New York City's 136 000 infants (New York State WIC program, unpublished data, 1994) and 1.7 million (43%) of this country's 4.0 million infants (US Dept of Agriculture, unpublished data, 1994). No other program has such high capture of the nation's preschool children and of urban children at highest risk. Our study data, despite their limitations, suggest that immunization initiatives in WIC may be facilitated by the ease of vaccination documentation—an essential precondition for effective immunization interventions—and by a programmatic emphasis on preventive care that may already have improved vaccination rates in the New York City WIC population over time.

As a result of preliminary analysis of data arising from this study, the intervention trial that followed,<sup>4</sup> and demonstration projects elsewhere, WIC has been made a major focus of national preschool immunization initiatives (joint letter from the director, National Immunization Program, CDC, and the director, Supplemental Food Programs Division, USDA, January 5, 1995). A 1995 survey of states indicated that 72% of local WIC agencies were screening enrolled children for their immunization status, with many providing other services as well.<sup>19</sup> Beginning in 1996, congressional appropriation language requires all states and localities receiving federal immunization grants to spend 10% of such funds on establishing linkages with WIC in accordance with guidelines set forth by the CDC. The final analysis of our study data provides support for this national initiative, but the unexpected finding of measles vaccination rates of more than 80% among the New

York City WIC population at the peak of a major epidemic underscores the need to achieve high coverage among these high-risk children to protect them against vaccine-preventable diseases. □

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## References

- Hutchins SS, Gindler JS, Atkinson WL, et al. Preschool children at high risk for measles: opportunities to vaccinate. *Am J Public Health*. 1993;83:862–867.
- Fuhrman J. Integrating immunization with WIC. Proceedings of the 25th National Immunization Conference; June 14, 1991; Washington, DC.
- Schlenker TL, Bain C, Baughman AL, Hadler SC. Measles herd immunity: the association of attack rates with immunization rates in preschool children. *JAMA*. 1992;267:823–826.
- Birkhead GS, LeBaron CW, Parsons P, et al. The immunization of children enrolled in the Special Supplemental Food Program for Women, Infants, and Children (WIC): the impact of different strategies. *JAMA*. 1995;274:312–316.
- Centers for Disease Control. Measles prevention: recommendations of the Immunization Practices Advisory Committee (ACIP). *MMWR Morb Mortal Wkly Rep*. 1989;38:1–13.
- SAS Institute Inc. *SAS/STAT User's Guide*. Release 6.03 Ed. Cary, NC: SAS Institute Inc; 1988.
- Zell ER, Dietz V, Stevenson J, Cochi S, Bruce RH. Low vaccination levels of US preschool and school-age children: retro-

- spective assessments of vaccination coverage 1991–1992. *JAMA*. 1994;271:833–839.
- Gustafson TL, Lievens AW, Brunell PA, Moellenberg RG, Buttery CMG, Sehulster LM. Measles outbreak in a fully immunized secondary-school population. *N Engl J Med*. 1987;316:771–774.
- Chen RT, Goldbaum GM, Wassilak SGF, Markowitz LE, Orenstein WA. An explosive point-source measles outbreak in a highly vaccinated population. *Am J Epidemiol*. 1989;129:173–182.
- Davis RM, Whitman ED, Orenstein WA, Preblud SR, Markowitz LE, Hinman AR. A persistent outbreak of measles despite appropriate prevention and control measures. *Am J Epidemiol*. 1987;126:438–449.
- Centers for Disease Control and Prevention. Vaccination coverage levels among children aged 19–35 months—United States, April–June 1994. *MMWR Morb Mortal Wkly Rep*. 1995;44:396–398.
- Himmelsstein DU, Woolhandler S. Care denied: US residents who are unable to obtain needed medical services. *Am J Public Health*. 1995;85:341–344.
- Henning KJ, Pollack DM, Friedman SM. A neonatal hepatitis B surveillance and vaccination program: New York City, 1987 to 1988. *Am J Public Health*. 1992;82:885–888.
- Wood D, Donald-Sherbourne C, Halfon N, et al. Factors related to immunization status among inner-city Latino and African-American preschoolers. *Pediatrics*. 1995;96:295–301.
- Arnold PJ, Schlenker TL. The impact of health care financing on childhood immunization practices. *Am J Dis Child*. 1992;146:728–732.
- Bordley WC, Freed GL, Garrett JM, Byrd CA, Meriwether R. Factors responsible for immunization referrals to health departments in North Carolina. *Pediatrics*. 1994;94:376–380.
- Ruch-Ross HS, O'Connor KG. Immunization referral practices of pediatricians in the United States. *Pediatrics*. 1994;94:508–513.
- Fairbrother G, Friedman S, Dumont K, Lobach KS. Markers for primary care: missed opportunities to immunize and screen for lead and tuberculosis by private physicians serving large numbers of inner-city Medicaid-eligible children. *Pediatrics*. 1996;97:785–790.
- Shefer A, Maes E, Brink E, Mize J, Passino JP. Assessment and related immunization issues in the Special Supplemental Food Program for Women, Infants, and Children (WIC): a status report. *J Public Health Manage Pract*. 1996;2:34–44.